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NAVAL POSTGRADUATE SCHOOL
Monterey, California

1981

THESIS

AN APPLICATION OF LIVING SYSTEMS THEORY TO COMBAT MODELS

by

Raymond R. Crawford, Jr.

March 1981

Thesis Advisor S.H. Parry

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A

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AN APPLICATION OF LIVING

SYSTEMS THEORY TO COMBAT MODELS

by

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Captain, United States Army
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Submitted in partial fullfillment of the
requirement for the degree of

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ABSTRACT

This thesis proposes a framework for incorporating organizational aspects in combat models. It begins by explaining Dr. James G. Miller's Living Systems Theory (LST) as a possible framework. Included in this discussion is a review of the basic nature and potential of LST. A review of the Army's involvement with LST and its present status is discussed. Recommendations are made for supplemental research which may help to develop this framework for the Army. A review explains present combat model limitations for describing organizational phenomena in combat. Finally, a methodology is proposed to integrate the results of LST into combat models of the future. Included as an Appendix, is a discussion of General Systems Theory which will help to explain the basis for LST.

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I. INTRODUCTION

A. GENERAL

Understanding all the aspects of an organizational system, such as the Army, is the subject of considerable interest to military planners. In an attempt to understand the organizational complexity of today's U.S. Army, senior military leaders have initiated communication with "philosophers and systems theorists." [13, p. 409] In a series of meetings between Pentagon officials and academics it was determined that the center of the problem was complexity. What the military was searching for was help in "holistically" visualizing how to deal with organizational complexity.

One example of a complex system without this holistic view was discovered during the "Nifty Nugget" exercise in 1978 [24]. This was the first government-wide mobilization exercise relying on computer models and data from many locations. It was conducted on the national level and used computers located at many different installations throughout the United States. The results of this exercise were called "devastating." [24, p. A-1] Three problems which contributed to the failure of this exercise were: incompatabilities of computer systems, logistics support miscalculations, and inability to control national resources. The organizational aspect that contributed to this disaster was the military's

emphasis on things rather than relationships, and hardware over concepts [13, p. 412].

Another example of this inability to model organizational aspects is seen in the military's method of introducing new technology. To aid the decision-makers, combat models are used to plan and predict future needs. These combat models attempt to describe the basic processes of battles and wars. They provide quantitative analysis on the hardware, but not the organizational aspects which will be affected. The ability to model organizational aspects in a logical and systematic manner continues to be a problem for analysts. The need for models which can identify whether new technology will cause dysfunctions in the organization is critical.

B. PURPOSE

In order to avoid such disasters in the future, organizational aspects should be considered. Specifically, this thesis will propose a systems framework for incorporating organizational aspects in combat models. In particular, Dr. James G. Miller's Living Systems Theory (LST) will be discussed as a framework.

In order to support this thesis, the following sequence will be used:

1. The essence of LST will be discussed as a particular general systems approach to understanding organizations.

2. The current Army research efforts on LST are summarized and future research requirements are suggested.

3. A possible methodology for applying LST results to overcome some limitations of current U.S. Army combat models is outlined.

4. The basic nature and potential of general systems theory will be clarified as a framework from which LST has evolved.

This study has been organized into five chapters and one appendix. Chapter II takes a particular approach of General Systems Theory (GST), the living systems approach, and describes in detail the concepts and definitions necessary for understanding it. Chapter III describes the current status of LST research in the Army. Additional analysis of LST, which is needed before it can be used by the military, will be discussed. Chapter IV identifies limitations of present military models in describing organizational phenomena of combat. A proposed approach using LST is suggested to correct these limitations. Chapter V, the concluding chapter, highlights key points yet to be resolved and follow-on actions for development of a framework. Included as an appendix will be a detailed explanation of concepts from GST.

Due to the incomplete application of Living Systems Theory the scope of this research effort was limited. Specifically, the Army's research efforts on LST have examined battalion level organizations. Therefore, this research

effort has addressed only those theories and models which emphasize battalion level organizations.

Given the complexity of Army organizations, this writer believes it is necessary for all people involved in building and using models to be aware of organizational aspects. Combat models in current use today do not yet reflect organizational aspects. Through a systems framework these organizational aspects can be incorporated into combat models.

C. SUMMARY OF GST CONCEPTS

In order to understand how Living Systems Theory (LST) evolved and why the Army has conducted research in it, an explanation of concepts from General Systems Theory is necessary. Because of the complexity of this approach a detailed explanation has been included in Appendix A. An explanation of the relationships and concepts of GST and LST are presented, providing the base from which LST has evolved.

The main purpose of the general systems approach is the integration of knowledge from all sciences. In order to accomplish this the GST approach has focused on three major points. The first is to look at problems from a large perspective. This is important to insure that both the system and the environment affecting that system are examined. This also insures that a general framework is built that can be filled in, as opposed to added on, as discoveries are made.

The second focus is on general relationships, or "patterns" of change. These patterns of systems assume no absolutes to insure that every aspect of a system is examined. The advantage here is that GST allows relationships between scientific disciplines to be discovered.

The final focus of GST is on a common language. This has the advantage of allowing different disciplines to communicate and facilitates the exchange of ideas.

II. LIVING SYSTEMS THEORY

A. INTRODUCTION

Chapter I explains that the Living Systems Theory (LST) is one particular part of GST. As Dr. Miller has stated, LST is an attempt to develop a general theory of behavior [51, p. XV]. His book, Living Systems, uses concepts and patterns from GST in a framework which categorizes and integrates a vast body of knowledge and research from many sciences. By concentrating on living systems he was able to build a detailed methodology for handling complex interrelationships and changes which occur in living systems. Included in this theory is research from the behavioral and social sciences which have been put in a conceptual framework which could be used to analyze organizational problems.

The purpose of this chapter will be to explain LST as it applies to organizations. This chapter has been divided into three parts. The first section will explain the purpose and basic concepts of LST. The second section will describe the 19 critical subsystems of LST. The final section will describe the relationships used to describe and examine living systems. Military examples will be used to illustrate the theory's applicability to the U.S. Army.

B. PURPOSE AND CONCEPTS

The purpose of LST is to produce a description of living structures and processes which will clarify and unify the "facts of life." [26, p. 71] In order to clarify these facts, Dr. Miller has chosen a subset of concrete systems called "living systems." To be considered a living system, Miller has identified nine specific criteria which a concrete system must possess. Seven of these are important to the discussion of organizations.

First, living systems are open. That is, they allow matter-energy and information to be processed as inputs from their environment. Likewise, they are able to process output to the environments when they are no longer needed in the system.

Second, living systems possess the ability to combat entropy. Through their ability to input matter-energy and information, living systems are able to maintain equilibrium. If a living system is closed off, such as in a seige, it will not be able to maintain this equilibrium and will die.

This ability to maintain equilibrium is closely related to the third attribute of living systems. Living systems can only exist in certain environments. Variables within the system have a narrow range of stability which when exceeded cause stress. If this stress cannot be adjusted back to normal the system will not survive. An example of this is man's need for a very precise body temperature.

Next, all living systems must possess a template or charter which delineates what the system consists of. In organizations this is a formal charter or constitution which defines the purpose of the organization.

Fifth, all living systems possess subsystems. These subsystems must be integrated together to work toward a unitary purpose and goal of the system. Organizations contain departments or subchapters which must be integrated and work for the same goals as the larger organization.

The sixth attribute of all living systems is that they must contain a decider. The decider must make decisions adjusting the interactions between subsystems and with the environment. The commander of a unit is the decider of that unit. If a living system, such as an organization, is totally dependent on another system to make deicisions then it cannot be considered a living system, but only a part or component of that other system.

Finally, LST specifies that all living systems must carry out 19 critical subsystem processes in order to survive. These 19 subsystems will be further delineated in the next section of this chapter.

In order to unify this theory of living systems, Miller has developed a hierarchy of living systems consisting of seven distinct levels. These levels are: (1) the cell, (2) the organ, (3) the organism, (4) the group, (5) the organization, (6) the society, (7) the supranational society.

Although Miller and others suggest these may not be completely distinct, formal identities have been developed using only these seven levels. One format Miller uses to emphasize the similarities of each level is to identify and explain in detail the same five elements at each level. He has attempted to show how living systems at each level have similar characteristics.

The first element is structure. Each level can be described in terms of structure. Structure is defined as the physical arrangement of components within a system at a particular point in time. The more complex a system becomes the more components it will contain. An example of components in an organization is the people. A representation of the structure of an organization is the typical organizational chart which shows the hierarchical and physical arrangement of components in an organization at a particular point in its history.

This can be differentiated from process, the second major element found at each level. Process is defined as a change in matter-energy or information over time. The process of making decisions for the organization is an example. A representation of process is a computer flow chart which lays out functions to be completed sequentially.

The distinction between structure and process needs to be made to point out that most studies of systems have concentrated on the structure rather than the processes. LST

uses both structure and process to show how a system integrates these to produce a unified system.

The third element which describes each level is its subsystems. A subsystem is all the structures in a system which carry out a particular process. As stated earlier, according to LST there are 19 critical subsystems.

The fourth element which can be used to describe each level consists of its internal relationships. LST has delineated three categories of internal relationships: structural, process, and relationships which involve meaning. These relationships will be further explained later in this chapter.

The final major element which can be used to describe each level of living system consists of systemwide processes. These are processes which may affect the entire system. They may require some or all of the subsystems to work together. Six of these systemwide processes have been identified. These, also, will be explained later in this chapter.

This section has defined the concepts which Miller has used to build this living system framework. These concepts both clarify what "living systems" are and help to delineate the magnitude and limitations which Miller has placed on this theory. As mentioned earlier, one of the unifying elements this theory has is the 19 subsystems of all living systems. These will be discussed next.

C. SUBSYSTEMS

According to LST, organizations require the proper operation of 19 critical subsystems. Figure 1 lists these 19 subsystems as a guide. These subsystems are identified by the components and the process each subsystem carries out. The decider subsystem must always be present. The other 18 subsystem processes may be "disposed" through parasitic or symbiotic relationships with other systems. A parasitic relationship is one in which another system performs one or more of these processes without receiving anything in exchange. A symbiotic relationship is one in which a system performs a process for another system in exchange for a service or reward from that system. An example of a symbiotic relationship is a military unit providing food and information to its soldiers in return for their performance of unit mission. These processes may be dispersed to a higher or lower level of living system. In a complex system, such as an Army battalion, one or more of these 18 subsystems may be dispersed. One example is the reproduction subsystem which is dispersed to the society.

An explanation of the 19 critical subsystems is provided below. A variation of these subsystem names has been suggested and is provided in parenthesis. A description and example of components usually involved in each process is included. The examples are from the military at the battalion organization level.

SUBSYSTEMS WHICH PROCESS

BOTH MATTER-ENERGY AND INFORMATION

Reproducer

Boundary

SUBSYSTEMS WHICH PROCESS MATTER-ENERGY	SUBSYSTEMS WHICH PROCESS INFORMATION
Ingestor	Input Transducer
--	Internal Transducer
Distributor	Channel and Net
Convertor	Decoder
Producer	Associator
Matter-Energy Storage	Memory
--	Decider
--	Encoder
Extruder	Output Transducer
Motor	--
Supporter	

FIGURE 1

19 Subsystems of Living Systems Theory

Subsystems Which Process Both Matter-Energy and Information

1. The Reproducer (replicating process) can produce, usually through a charter or template, another system similar to the one of which it is a part. It differs from other subsystems in that it produces new complete systems by bringing together both matter-energy and information. As stated earlier, this is usually accomplished outside the military by a higher level system, the society. This process is usually accomplished in response to a present or predicted demand for certain products or services. The creation of a Rapid Deployment Force is a current example of the replicating process.

2. The Boundary (enclosing process) is at the perimeter of an organization and is used for protection, filtering, and holding together the components of the organization. The components of the organization may be matter-energy boundaries, such as guards at an entrance to prevent people and equipment from entering; or they may be information boundaries, such as the security officers of a unit who screen classified information as it enters or leaves the unit.

Subsystems Which Process Material-Resources

3. The Ingestor (receiving process) brings matter-energy (resources and materials) across the boundary of the system. This process can be utilized to bring in both non-living matter-energy, such as ammunition or spare parts, and living matter-energy such as the replacement of troops.

Army battalions have separate and multiple components designed for this purpose such as the S-4 and S-1.

4. The Distributor (distributing process) carries material and resources around the organization to each component, whether it be inputs from outside or products produced within the system. Couriers and supply clerks are components involved in this activity.

5. The Convertor (transforming process) changes certain matter-energy inputs into a form which can be used by other parts of the organization. One example at the battalion level is the component of the mess section involved in butchering meat or peeling potatoes prior to preparing the meal. For some organizations this process may be accomplished by an outside group, such as converting crude oil into different types of fuel prior to its distribution by unit fuel trucks.

6. The Producer (producing process) makes products needed by the system itself and/or other systems. This process is used to synthesize material for growth, repair, or replacement of system components. It also provides the energy to move these products out of organization. Examples include components involved in cooking food, maintaining equipment, and killing enemy tanks.

7. The Matter-Energy Storage (storing process) subsystem retains various deposits of matter-energy within the organization for future use. This process requires a

certain amount of maintenance to prevent deterioration or theft, and the ability to find items when needed. Components of the battalion that are responsible for maintaining inventories of spare parts, fuel, food, and ammunition are involved in this process.

8. The <u>Extruder</u> (removing process) removes matter-energy from the organization either as a product or waste. Products will be types of matter-energy which contribute to the organization's purpose and goal such as a well-trained soldier or bullets on the way to a target. Wastes are types of matter-energy which do not contribute to the purpose and goal of the organization and thus are excess. An example of components involved in this process is personnel involved in disposal of expended ammunition.

9. The <u>Motor</u> (moving process) moves the organization or parts of it. This process may be accomplished by components which contain their own independent subsystems, such as companies moving themselves by using their own equipment.

10. The <u>Supporter</u> (supporting process) establishes the structure of the organization and maintains the proper spatial relationships among components. This process allows for interaction without interference (exemplified by crowding or weighting down of components). Components involved in this process include the operations officer's timetable for movement of the unit, or the commander's positioning of units prior to battle.

Subsystems Which Process Information

11. The Input Transducer (inputting process) brings markers bearing information across the boundary of an organization and transforms them into a form useable within the organization. This process may consist of components which change information into material-resources, as exemplified by a phone conversation being written down. Examples of this process include intelligence reports being received by radio, or the activation of early warning systems.

12. The Internal Transducer (monitoring process) receives and monitors information markers from components and other subsystems of the organization. If necessary, this process changes these markers into material-resources which can be transmitted within the organization. This process is accomplished by components which monitor the internal processes of the system, such as an ombudsman or internally organized inspection team reporting on vehicle maintenance.

13. The Channel and Net (circulating process) transmits information markers to all parts of the organization without changing their form. This process may be accomplished by single one-way routes or multiple interconnected routes which form a net to circulate information. Examples of components are the telephone or radio.

14. The Decoder (decoding process) changes the code or language of information input to it into a "private" code to be used internally by the organization. This alteration

may be necessary for information coming from the environment (through the input transducer) or from other subsystems within the organization (through the internal transducer). Examples of components which conduct this process are the deciphering of secret messages or the interpretation and synthesis of an operations order for different staff sections.

15. The Associator (relating process) carries out the first stage of the learning process by forming patterns or relationships among items of information within the organization. Information used in this process comes from the input transducer, internal transducer, or memory (see below) and is evidenced when changes in other processes appear. According to LST, this process is downwardly dispersed to the individuals within the organization.

16. The Memory (remembering process) carries out the second stage of the learning process by storing information for various periods of time until it is needed by the organization. Like matter-energy storage, the memory process requires the ability to input, maintain, alter during storage, and retrieve information when called upon. Components of the organization involved in this process include battalion file clerks, computer operators, and unit historians.

17. The Decider (deciding process) is the executive subsystem. It receives information inputs from all other

subsystems, takes action and transmits information outputs to control all components and processes of the organization. The decider component of an organization reduces the amount of information through the processes of setting standards, resolving conflicts, developing plans, allocating resources, and evaluating performance. As stated earlier, this is the only subsystem which cannot be dispersed to another level. However, this process may be laterally dispersed to more than one individual or group depending on the need for power, authority, or influence within the organization. Examples of components performing this process are the executive officer, headquarters' staff, or peers within the organization.

18. The Encoder (encoding process) alters the code or language of information to it from the "private" to the public code for use outside the organization. This process is the reverse of the decoder, but may also be utilized as an editing process to ensure that only information which the decider approves leaves the organization. Examples of components which conduct this process are soldiers involved in coding of secret communications, groups or individuals that write or edit reports to higher headquarters and translators.

19. The Output Transducer (outputting process) transmits information markers from the organization by changing the form of the markers into a useable form for the

environment. This process may be centrally controlled by the decider since the organization's relationship and commitment to other organizations will be affected through this process. Components which exemplify this process are radio operators and public affairs officers.

One aspect of these subsystems that helps to unify the different levels of living systems is the concept of shred-out. Shred-out is the progressive division of labor and specialization of functions within these subsystems as the level of complexity increases [51, p. 1033]. The more complex a system becomes, the more components it will have. However, all systems, at all levels, perform only these 19 critical processes. This provides a link between each level of living system. As an example, the process of deciding is done by the individual at the organism level, but many components may be required to perform this one process at the organization level.

Another aspect of the 19 subsystems is Miller's measurement of them, using variables and indicators. Any property of a system or relationship within a system which can be recognized and which can potentially change over time can be used as a variable. Miller has identified 12 variables which can be used at all levels to measure these 19 subsystems. An example of a variable is the <u>cost</u> of the ingestor subsystem to the organization. Most of these variables in an organization can be measured by specific

operations, techniques and/or instruments which are called indicators. Specific indicators must be identified by the observer in order to measure these variables. As an example, to measure the cost of the ingestor process, one could measure the amount of time all components of an organization spent on that process.

D. RELATIONSHIPS

Each living system exhibits a variety of relationships which are in continual adjustment. Figure 2 shows an organization involved in the 19 processes and some of the interaction that can take place. According to LST, these relationships may be generated by two types of interactions: the internal relationships within the critical subsystems or by systemwide processes. At each level of living system, Miller has identified these relationships in order to illuminate how these systems perform this adjustment. An explanation of these relationships is necessary to show how LST can be used to delineate these 19 subsystems. According to LST, these relationships can be measured; and in Miller's book examples of how to measure these relationships for each level are given.

Internal relationships have been identified in three major categories. The first, structural relationships, help to explain how living systems are arragned spatially. Examples of structural relationships are provided for each level

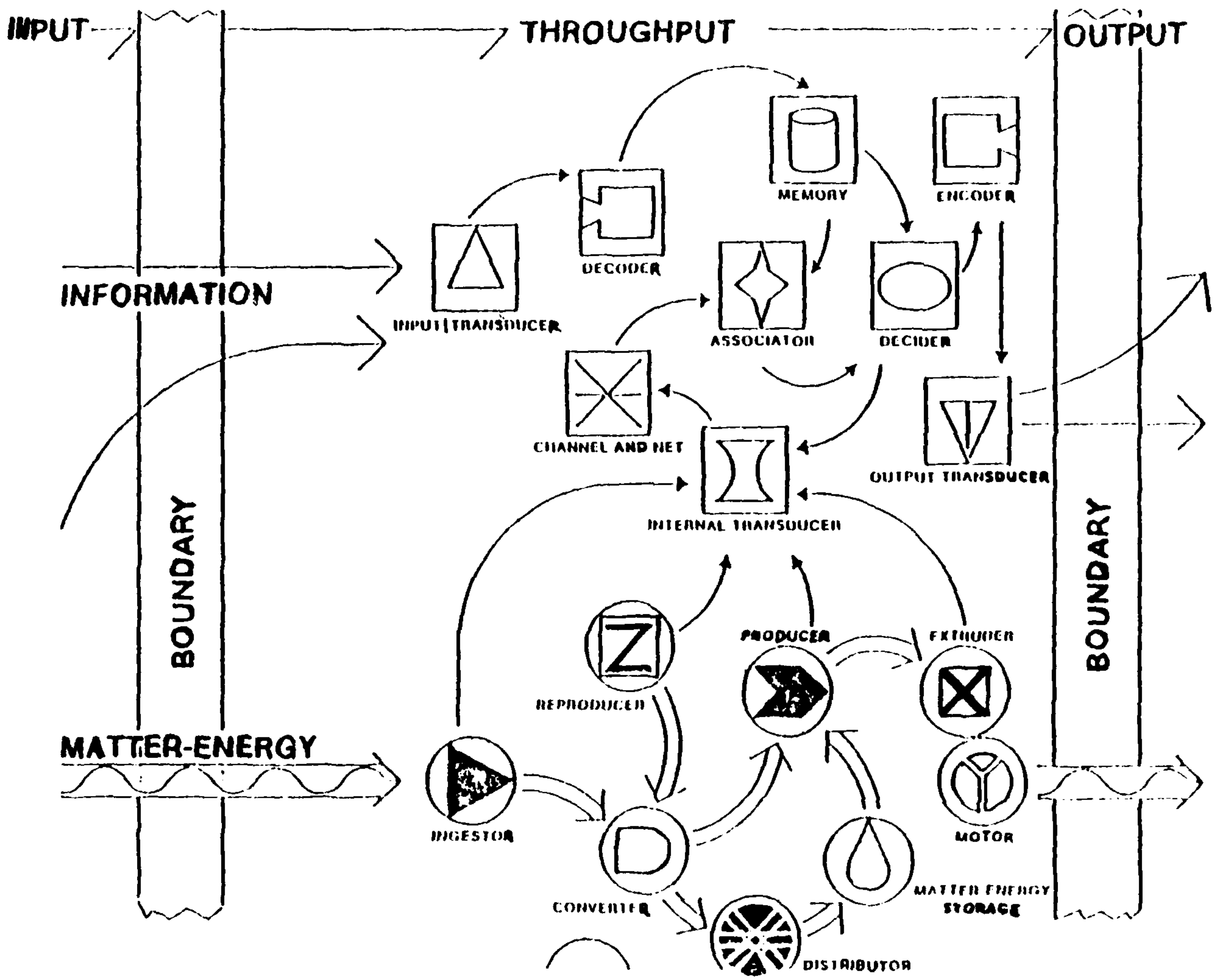


FIGURE 2

Example of Systemwide Process Interaction

of living system. An example of a structural relationship at the organizational level is the size of a battalion.

The second relationship is the process relationship among subsystems. Process relationships are of a temporal nature and/or may involve a structural change over time. An example of a process relationship is the frequency (or number of times) different processes interact with each other over a given time. In the battalion the number of vehicles that are sent back into combat each day is an example.

The third relationship among subsystems is the relationship involving meaning. Meaning is differentiated from information in that meaning is the effect information has on subsystems or components. These relationships involve interpretation and today these relationships are subject to inadequate measures of quantification. An example of this relationship is when the training officer interprets a commander's orders.

The second type of interaction involves united efforts by some or all of the 19 subsystems. These systemwide processes affect the entire organization and as such require multiple-subsystem evaluation. Six of these systemwide processes have been identified. Again, Miller has explained these six processes at each level with specific examples. These processes can be likened to the patterns mentioned in GST.

The first systemwide process is the relationship between inputs and outputs. Conclusions about the entire system can be made by observing relationships between inputs and outputs of both matter-energy and information. An example of this would be to measure the amount of ammunition a unit had received and the amount it had used up to determine if it had enough to continue fighting.

The second systemwide process is the adjustment process which makes alterations in matter-energy and/or information to accomodate stress. This is similar to the morphostatic pattern of change from GST. In LST in addition to morphostasis living systems also require homeostasis. Homeostasis is the tendency of living systems to maintain an orderly balance among subsystems. This adjustment can be observed as matter-energy or information used in input, used internally, or used in output from the system. An example of a matter-energy input adjustment would be the requirement to increase the rate of ammunition supply to a unit in combat.

The third systemwide process is the evolutionary processes which are caused by the environment. According to LST these processes cause a change in the structure and/or processes which is often irreversible. This is similar to the morphogenic changes of GST. LST asserts that the general direction of evolution is toward systems with greater complexity in both structure and process [51, p. 76]. As a result of this process higher levels of systems are

formed with characteristics not found in simpler systems. These new structures and processes are referred to an emergent characteristics. Miller uses these characteristics as one of the bases for defining the seven different levels (for examples of these emergent characteristics see Miller [51, pp. 1036-1038]).

The fourth systemwide process that Miller describes is also a morphogenic change. In LST this process deals with growth, cohesion and integration. These three processes have been separated because they involve a conscious effort on the part of the system to adjust to the environment. Growth can also result in a higher level system with emergent characteristics. Cohesiveness is a coordinated effort which requires contact between system parts and components. Given a minimum amount of cohesion an organization can integrate its parts toward a goal or objective [21, p. 518].

The fifth systemwide process is pathology. Pathologies result from the lack of matter-energy or information in a system. Miller points out that these are difficult to analyze without a common standard on which to base the analysis. However, he has identified eight different types of pathology. One such example is the lack of information input to an organization. In the military we recognize the need for information and the consequences of insufficient information. What is needed is a standard which can be used to determine if a pathology exists in information input.

The sixth and final systemwide process is decay or termination. This is similar to the metamorphic pattern of change in GST. According to LST and GST, this process is defined as equifinality. Some living systems, such as man, decay and terminate based on age. Other living systems, such as organizations, are terminated due to dysfunctions which cannot be corrected.

As a conceptual framework, Miller has provided an illustration of these relationships within subsystems and at each different level of living system. What is needed is the quantification of these relationships which Miller states will only occur through research using this LST framework.

E. SUMMARY

The purpose of this chapter has been to explain the conceptual framework and methodology of LST. This was accomplished by explaining the subsystems and relationships in organizations as they are applied by LST. Through the use of the LST framework a comprehensive, systematic measurement and diagnosis of Army units can be made. The 19 subsystems of LST provide an explicit framework for identifying organizational aspects. However, the relationships of subsystems need to be quantified through application. In the next chapter a specific diagnostic strategy for measuring these relationships in the Army will be described using LST. The limits of this Army research effort will be explained. The utility of LST for military problems will be discussed.

III. APPLICATION OF LST TO THE ARMY

A. INTRODUCTION

Miller concludes his explanation of LST with an emphasis on the need for practical applications which will verify his theory and assess its utility in solving specific real world problems. This chapter will show how the Army became involved with LST and how it has attempted to apply this theory in explaining two peacetime military problems. The results of two research efforts will be examined in an attempt to give the reader an appreciation for the complexity involved in using this approach. Finally, possible future improvements and applications will also be explored in order to establish a starting point and road map for future research. This chapter will begin with an explanation of how the Army becamed involved with LST.

B. U.S. ARMY INVOLVEMENT

The Army became involved in Living Systems Theory when a group of senior Army planners attempted to resolve the difference between the Army's actual and potential force readiness. Originally organized as Task Force Delta, the group consisted of 50-60 Army officers from many areas of expertise. They were brought together to view the Army as a whole system; to define how it runs; and to attempt to

identify the solutions to its many problems. The impetus for this organization's formation is clearly evident in its basic problem statement: "Understanding that we must work through people, how can our Army establish and maintain control of changing interdependent systems to maximize force readiness." [44, p. 1]

Once work was begun, it became obvious that the problem was not going to be solved easily, nor would it be solved only by people within the Army. The solution which was reached is discussed in Colonel D.M. Malone's concept paper "X=H" [44]. The Task Force concluded that the key to solving this complex problem would be "matter-energy organized by information." [44, p. 4] What has evolved, as explained in Malone's paper, is a view of the Army as a <u>system</u> which needs to increase efficiency and effectiveness through an understanding of organizational processes. Also produced at the same time was another concept paper by Lieutenant Colonel William W. Witt, entitled "Information Engineering" [71], which dealt specifically with the problems of diagnosing and correcting problems in information processing of military units.

In the spring of 1979, the University of Louisville was contacted by the newly formed Systems Doctrine Office at TRADOC Headquarters and was asked to conduct an exploratory analysis using the LST framework.

D. SYSTEMS SCIENCE INSTITUTE INVOLVEMENT

The Systems Science Institute (SSI) was developed and organized by Miller at the University of Louisville with the specific objective of conducting research, and training graduate students using a systems science methodology. The research conducted is predominantly of a quantitative nature. The SSI uses an interdisciplinary approach to solving real world problems. General systems ideas and specifically Living Systems Theory have been applied to many problems. Examples of LST applications have been reported in the health delivery systems area by Whitehead and Brown; in industrial organizations such as General Motors by Duncan; and for the City of Louisville by Vandevelde and Miller [19]. Most recently, SSI's examination of LST applicability to the Army has produced two reports which will be discussed in detail.

D. REPORT METHODOLOGY

In order to clarify the results of the two reports, an explanation of the procedure used to conduct the research is necessary. The research was conducted in four stages. First, the data was collected by interviewers, both from the SSI and from the Army. The "instruments" they used to collect data were questionnaires and inverviews of key personnel. These personnel were questioned about their job and how it related to the subsystem processes. The form of this data can be found in Appendix B of the first report [57].

The second step in the research was to rank the battalions in terms of unit effectiveness. This was done by constructing a "composite index of unit effectiveness." [57, p. 49] This composite index consisted of three parts: command indicators (CI), performance indicators (PI), and perceived efficiency of unit effectiveness (PE). The command indicators and performance indicators were obtained from traditional data maintained at the units. Examples of these are Annual General's Inspection (AGI) results, and reinlistment results. The perception data was collected on Training Status Questionnaires (TSQ). The answers to the TSQ were perceptions from personnel such as the brigade commander, the battalion commander, and the training officer. The composite value for each battalion was obtained using a "multiplicative utility function" [57, p. 49] for each of these three parts. Based on the ranking obtained in all three parts, an overall composite ranking was made. This ranking was compared with a weighting of the three parts suggested by a Deputy Chief of Staff for Personnel (DCSPER) formula described below:

BER = 1/6 (CI) + 1/3 (PI) + 1/2 (PE) [57, p. 51]

Once ranked, the battalions were placed in a category. For the first report, it was high and low categories. For the second report, it was high, medium, and low. These categories were used throughout the rest of the analysis.

The third step of the research involved analysis of the categories in terms of how they perfomed the processes, using the remaining questionnaires and interview data. A variety of parametric and non-parametric techniques were used to establish the relationship between the processes and five variables chosen to identify these processes: cost, time, meaning, lag, and distortion. The results of this analysis revealed that process variables were associated with "unit effectiveness" and the other subsystems [57, p. 131].

The final step of the analysis was to summarize the results based on processes and components (i.e., battalion commanders, battalion executive officers, and training officers). Again, analysis was done using data from the high, medium, and low categories. The results in the summary contained only general findings as opposed to quantified data for two reasons. First, the small sample size used in both research efforts prohibited statistically significant conclusions to be drawn. Second, the results were based on BER's. As a new technique for assessing unit effectiveness in peacetime, BER's are not accepted as an Army standard.

Together these four steps represent a detailed method of obtaining both quantified data and perceptions about a unit. These results give a unit commander a description of his unit in terms of the 19 processes.

E. LST ARMY FEASIBILITY STUDY

The first report produced by SSI was funded by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) and TRADOC. The purpose of this research effort was to assess the relevance and utility of LST for understanding and maintaining control of changing inter-dependent systems in the Army [57]. The research team limited itself to four specific objectives:

1. Identify and measure efficiences of nine information-processing subsystems with respect to Training Management Activities (TMA) in six Army Battalions.

2. Analyze the activities or functions of key components within each subsystem from the standpoint of LST.

3. Describe and delineate the efficiencies of LST subsystems for measuring unit effectiveness over traditional measures used by the Army.

4. Diagnose organizational pathologies and suggest possible approaches to solving these problems using the LST perspective.

The results of this research effort found both a descriptive and a diagnostic utility for LST as a research technique to be used in the Army. Specifically, the report was able to achieve its objectives in these four areas:

1. The concepts and instruments used to measure LST were able to be understood by Army personnel and appeared to

be useful in explaining how to view their own tasks within the battalion.

2. The living systems approach was able to describe, in more detail, the internal information processes between sections within the battalion. The subsystem analysis approach permitted an examination of the nine information processes and unit components (e.g., commander, executive officer, and S-3). The measurement of the nine processes used the five variables of cost, lag, distortion, meaning, and volume. Figures 3 and 4 are an example of the cost variable results by subsystems and by components.

3. The living systems approach was able to distinguish among Army battalions, in much the same way as traditional measures of effectiveness, with less disruption of unit activities and more insight into specific process differences. This was done by comparing traditional measures of effectiveness, such as Annual General's Inspection (AGI) results, to the results of the five variables. As seen in Figure 5, the "healthiest" battalion contained values of variables in an acceptable range (i.e., dark area), while in Figure 6 the "unhealthiest" battalions were only acceptable in one area (volume).

4. The living systems approach was able to identify specific pathologies among components within battalions in terms of its "health ratio." The ability to identify and

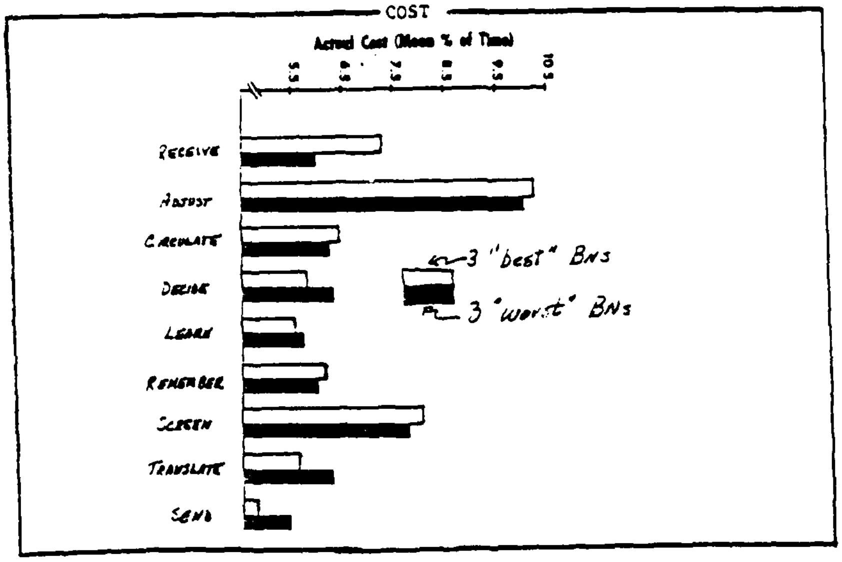


FIGURE 3
Results of Variable "cost" on 9 Subsystems

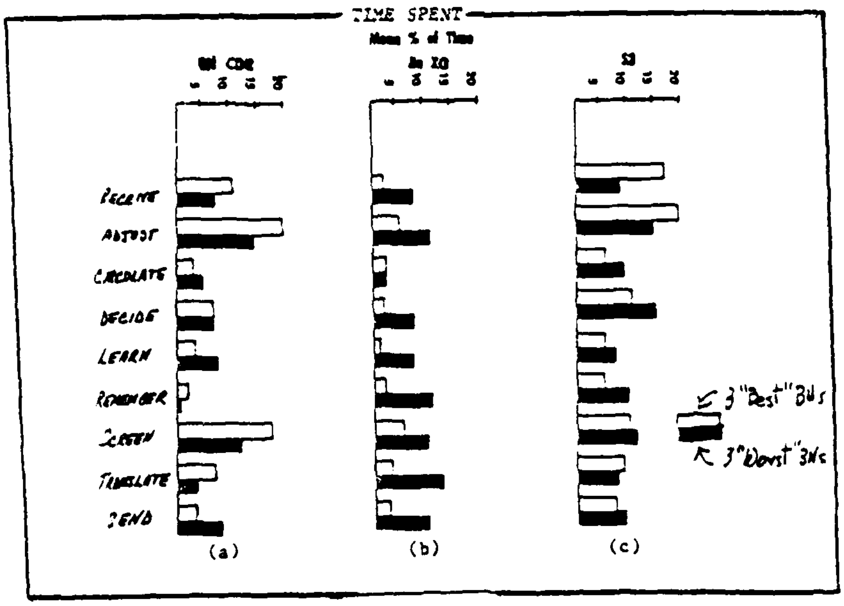
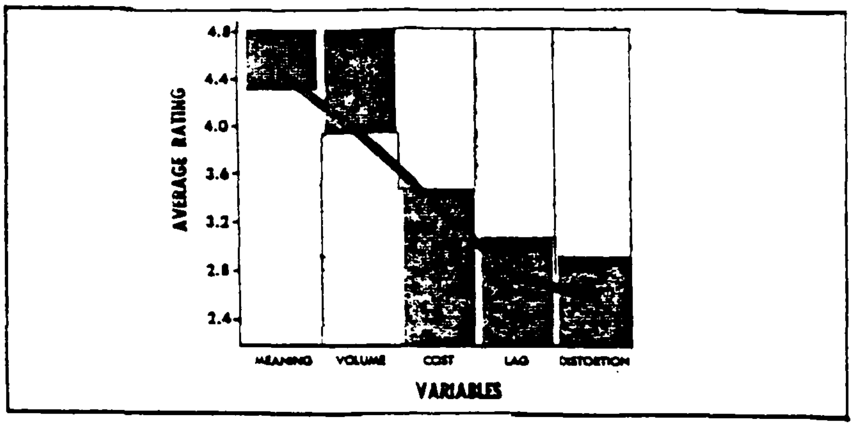


FIGURE 4
Resuls of Variable "cost" on 3 Components

FIGURE 5
Profile of "Healthiest" Battalions



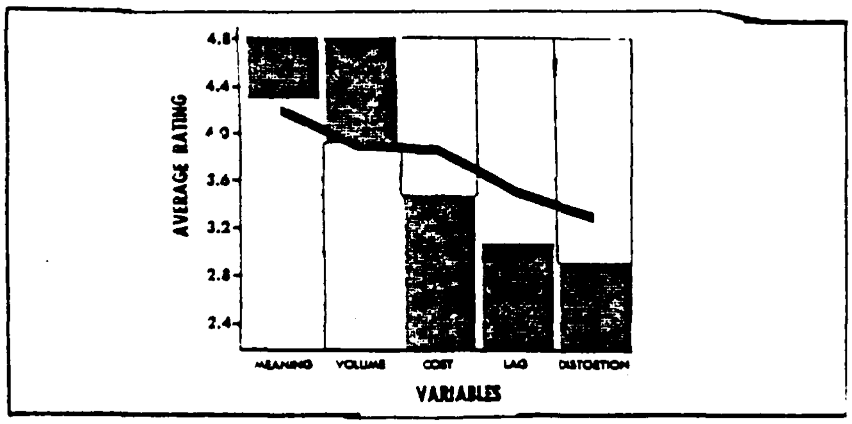


FIGURE 6
Profile of"Unhealthiest" Battalions

and distinguish five variables in these units shows practical utility for monitoring and improving the Army as a whole.

The four general findings, along with the instruments, personnel expertise, and suggested power of LST were received with a great deal of interest at the Department of the Army and Department of Defense level. As a result, a much larger research effort was started at the SSI.

F. LST EVALUATION OF BATTALION TRAINING MANAGEMENT SYSTEM (BTMS)

The success of the first project prompted the undertaking of a second. This study is being sponsored by the U.S. Army Training Board and ARI [66]. Using LST as a framework, the project is attempting to evaluate the Battalion Training Management System (BTMS). BTMS has been implemented in many Army units and LST is being used to evaluate its effect. Again the emphasis is on peacetime training management, but the research is expanded to evaluate the effects of BTMS in all 19 subsystems, as well as the related areas of personnel and logistics management. The research focuses on five goals:

1. Describe the processing of information and matter-energy in Army battalions for peacetime training management.

2. Relate the quality and quantity of these processes, within the unit, to unit effectiveness.

3. Develop analytical techniques and refine the instruments which identify those processes that impede unit effectiveness.

4. Provide the units that participated in the research with timely feedback as to the results of this analysis.

5. Propose techniques for improving information and material-resource processing to enhance unit effectiveness.

In this project the researchers increased the size of their sample to thirty-five different units from both U.S. Army Forces Command (FORSCOM) and U.S. Army Europe (USAREUR) with a total of 5170 personnel being interviewed. Included in this data base are different types of units from combat, combat support, and combat service support units. Personnel were interviewed and files were reviewed in the areas of training (S-3), personnel (S-1), and logistics (S-4). Several different types of instruments were used to gather data on the 19 processes. The final analysis only included 17 of the 19 processes, with the reproducer and the boundary being left out of the analysis.

The magnitude of this data base caused a significant problem for analysis but was managed by three forms in which the data had been collected: traditional, perceptual, and objective. The traditional unit data, which consisted of items from the first two columns of Figure 7, was used to develop a battalion effectiveness ranking (BER) for each unit as mentioned in the preceding section. The BER

BATTALION EFFECTIVENESS RANKS (BERs)

PERFORMANCE INDICATORS	COMMAND INDICATORS	PERCEPTIONS
% REQUIRED EQUIPMENT READY	% RE-UP QUOTA - 1ST TERM	SOLDIERS
% SQT GO .	-CAREER	SQUAD, CREW OR SECTION LEADERS
% CBR QUALIFIED	# ADVERSE PERSONNEL ACTIONS	PLATOON LEADERS, PLATOON SERGEANTS
% .45 CAL QUALIFIED	% STRENGTH - OFFICER	CSM, 1SG
% RIFLE QUALIFIED	-ENLISTED	BN CDR & STAFF, CO CDR & STAFF
% PT QUALIFIED	% GRADE SHORTAGE - OFFICER	*BDE CDR & STAFF*
% *TEAM QUALIFICATION GO*	% *MOS TRAINED*	
	% SENIOR GRADE	
	% MONTHLY TURNOVER	
	TRAINING FACTOR AVAILABILITY	

FIGURE 7

BATTALION EFFECTIVENESS RANKS

rankings of high, medium, and low were used to simplify analysis. The perception data was gathered from several different questionnaires and was used in analyzing four different perspectives: state, time, rank of importance, and performance. These four perspectives were considered variables in living systems terms. (See Figure 8 for example of data base.) Finally, the objective data was collected from the three staff sections (i.e., S-1, S-3, and S-4) in an attempt to relate unit perceptions of processes to regularly maintained data in the unit. An example of objective data is publications missing or on order; reports of survey initiated; and personnel transactions over a specified period of time. In analyzing this data, in the context of the second report, only a small percentage (approximately 10%) has been used.

Although at this time the final report has not been written, preliminary results of this project are available. Due to the significance of the results, many of the staff and command agencies in the Army have been briefed on the findings. The purpose of these briefings has been to let the Army know a new tool may soon be available to the Commander which will give him a more complete picture of his unit's internal processes. Specifically, the research has found that:

1. All Army battalions are living systems and can be described in terms of the 19 critical processes of LST.

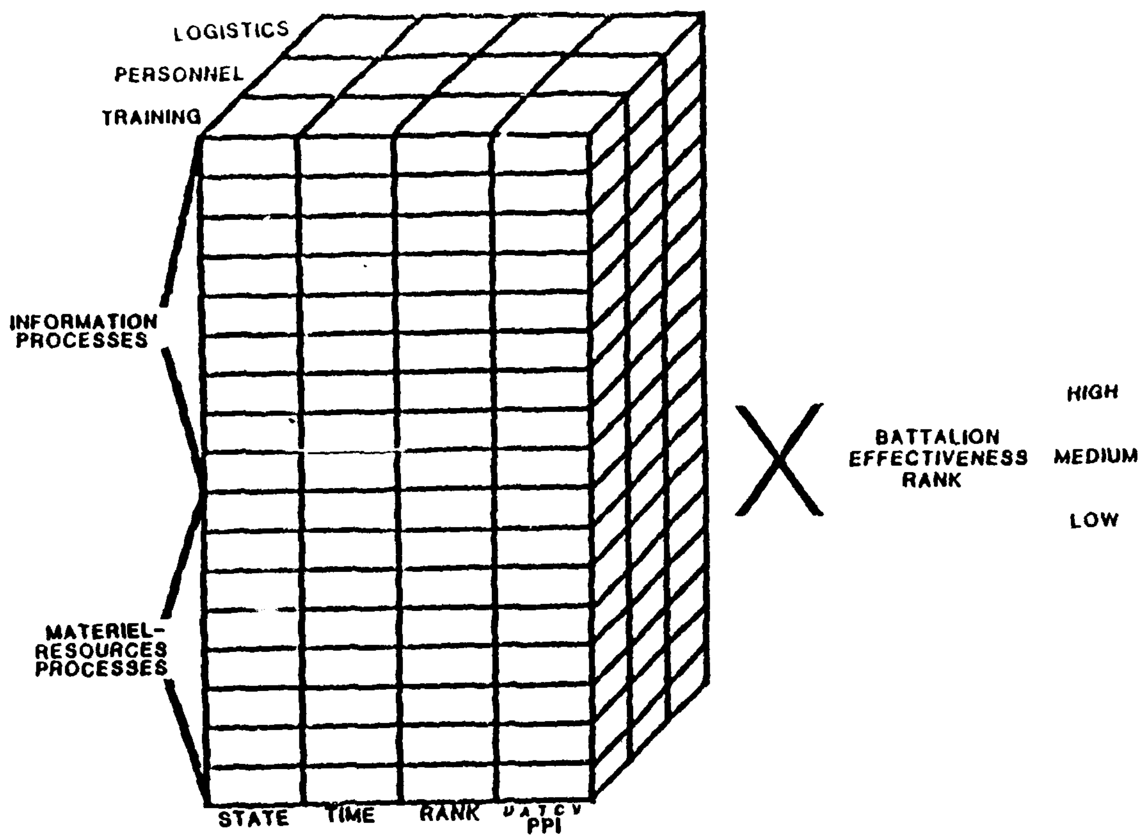


FIGURE 8

DATA BASE FOR SECOND ARMY PROJECT

(See Figure 9 for an example diagram of all 19 processes.) The LST framework can be understood by military leaders and used to explain more fully the functions and processes interacting within their units.

2. Unit effectiveness, in terms of quantity and quality of these processes, can be used to differentiate among sections within units and between different battalions.

3. The instruments (i.e., questionnaires and personnel interview sheets) and analytical techniques to identify and distinguish peacetime unit effectiveness have been developed.

4. All units participating in the research were notified with 45 days of their particular strengths and weaknesses in terms of the 17 subsystems. In each report, particular pathologies were identified and possible solutions were suggested.

5. The LST technique which was used in both projects to gather data has been useful for identifying possible problems in the Army units. However, the SSI is recommending that to resolve these problems the unit commander should be assisted by an Organizational Effectiveness Staff Officer (OESO). The OESO is a trained facilitator in conducting change in organizations. The OESO also has the accessibility to the unit which allows this change to take place without disrupting the unit.

The results of these two projects have caused great strides to be made in analyzing the applicability of LST to

ARMOR BATTALION TASK FORCE AND TRAINS

All Processes

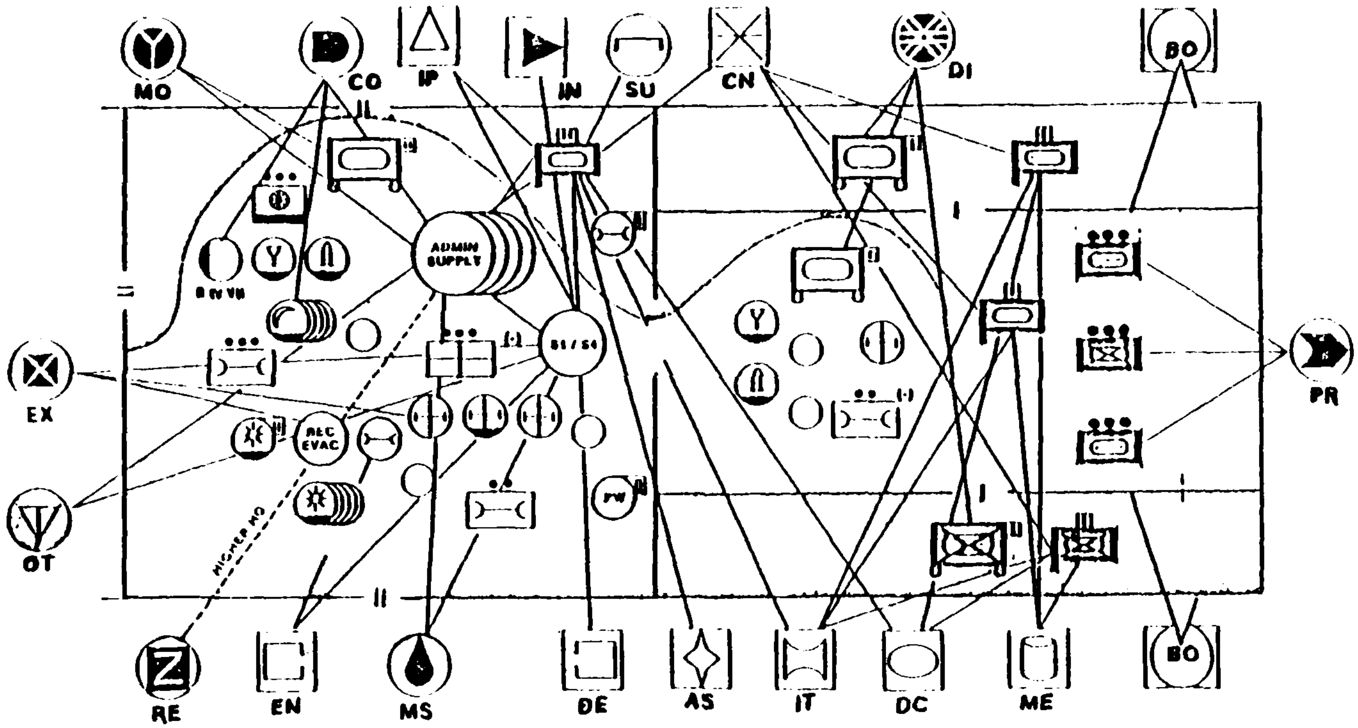


FIGURE 9
19 SUBSYSTEMS IN OPERATION

solving Army problems. Specifically, the research has shown that living systems framework can be used for description and diagnosis of Army problems in peacetime. Based on the research thus far, "description" means the 19 critical subsystem processes can be found in Army units. Also, based on the results so far, "diagnosis" means the research has been able to show that there are differences between Army units, based on these subsystems. In the process of developing the results, specific future directions have been proposed which must be evaluated by the Army.

G. THE PROPOSED FUTURE ARMY INVOLVEMENT

As stated earlier, the living systems framework has been used successfully to describe how Army units function. However, six specific needs must be resolved before this approach can be used by the Army.

The first need is for an organization within the Army that can continue research using the living systems approach. Specific research must be identified based on the present status of the research effort and the needs of the Army. TRADOC has proposed an organization to coordinate this effort called the Institute for Systems Science Research and Training (ISSRT). (See Figure 10 for the proposed organizational structure.) The purpose of this organization would be to assist in resolving the next five needs.

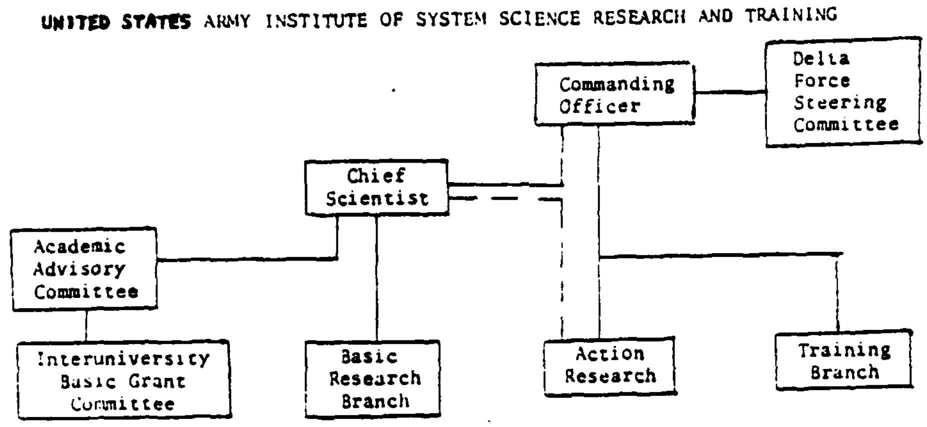


FIGURE 10

PROPOSED ORGANIZATION FOR ISSRT

The second need is to either strengthen the validity of the battalion effectiveness rankings (BER's) or eliminate them from the analysis. Questions still remain concerning the validity of the utility function chosen to rank command indicators, performance indicators, and perceptions. As mentioned in the first report, results from unit Army Training and Evaluation Programs (ARTEP) and the Soldier Qualification Test (SQT) results have not been included in these BER's [57, p. 51]. These are two major programs for which units are training and should be included in the evaluation of unit effectiveness.

The third need is to complete the analysis of the present data. Due to the size of the existing data base, the analysis has only shown possible indicators of problems based on "typical" Army units. A typical Army unit was evaluated using the high, medium, and low BER's. What is needed is quantification of internal relationships of structure and process based on specific type units. One approach would be to group these units into combat, combat support, and combat service support type units. This serves two purposes. The first is the reduction in the size of the data base being analyzed. The second is that each of these units has a different mission in combat. These units require different processes to be emphasized and components to be structured differently. For example, the Infantry in combat moves at a much quicker pace during combat than a

transportation battalion. The perceptual data already gathered has these different type unit relationships and systems processes incorporated into them. In order to measure unit effectiveness, similar type battalions need to be compared in terms of like relationships and processes.

The fourth need is related to the second. There is a need in the future to make assessment packages (question-naires and interviews) more branch specific. Artillery units are not structured, nor do they process information, in the same manner as an Infantry unit. Therefore differ-ences need to be reflected in assessment packages based on specific internal relationships discovered during future analysis. One result would be a common language for all artillerymen and a more homogeneous sampling from each branch.

The fifth need is to make these assessments more useful and productive for the unit. The results of the present research effort reveals that the present format of assess-ment requires excessive time (for both the unit and the assessor), is resource intensive (in terms of computer time and manpower), and the analysis provides only a diagnosis of the unit. These two requirements of time and resources allow only one assessment to be conducted on a battalion. Battalions are continually changing over time due to per-sonnel changes and need to be assessed as to how these pro-cesses are functioning. Battalions need feedback in a more

timely manner if the LST assessments are to be useful. The LST framework suggests an ability to diagnose why and prescribe how units should function. In order to do that at least two assessments need to be conducted to provide this feedback.

The sixth, and final, need that must be resolved is to relate unit assessment to combat. The most accurate method would be to evaluate a unit in combat. Since this is not currently feasible nor desired, a combat simulated environment needs to be exercised. Two methods which are available are field training exercises or controlled combat experiments. Field exercises conducted at the National Training Center (NTC) provide the necessary amount of "combat" to evaluate unit relationships and systems processes. A more limited exercise could be conducted in the Combined Arms Tactical Training Simulator (CATTS) located at Fort Leavenworth, Kansas. This trainer is a 48 hour simulated battle for battalion staffs. The comparison between how a unit functions in peacetime and simulated wartime could reveal two things. First, it could help identify and quantify internal relationships and organization processes that are critical during combat. Second, it could reveal the change a battalion staff must go through betweem peacetime and combat. Both of these methods of assessment would help to establish more realistic norms that can gauge unit effectiveness in combat. Included in the results of these tests

would be more precise data on how organizations process matter-energy and information during combat.

H. SUMMARY

The purpose of this chapter was to explain the Army research effort using LST. This was accomplished by describing the purpose and results of two projects already conducted. As emphasized, there still exists a need for more research into quantification of relationships and processes using the living systems framework. Specific needs and future research have been discussed.

One particular area which also could benefit from this future research is the modeling community within the U.S. Army. The LST framework can be used to diagnose organizations. A method to use these results must be developed and used in combat models. A discussion of this potential source of information for models will be discussed in the next chapter.

IV. AN APPROACH TO MODELING MILITARY ORGANIZATIONS

A. INTRODUCTION

A recently completed study done by David C. Hardison, entitled "Review of Army Analysis" [29], called for a reorganization of Army modeling and analysis activities. In the report he emphasized the need to better utilize the Army's resources and improve the quality, focus, and efficiency of Army analysis. Throughout the report mention was made of the inadequacies within the different agencies in their ability to model and analyze the Army as an organization. The results of this report were the establishment of an Army Model Improvement Program (AMIP) with an Army Models Committee (AMC) for control purposes [65]. The idea behind reorganization was the establishment of a hierarchy of models with an integrated data base which would, in theory, prevent duplication of effort and allow for a family of Army combat and support models for analysis purposes. As illustrated in Figure 11, the lower level model would provide combat results for the next higher level. At the same time the higher level model would provide scenarios to the lower level. Included in this scheme is the integrated data base that must be established.

The purpose of this chapter is to describe a methodology for applying LST results to overcome some limitations of

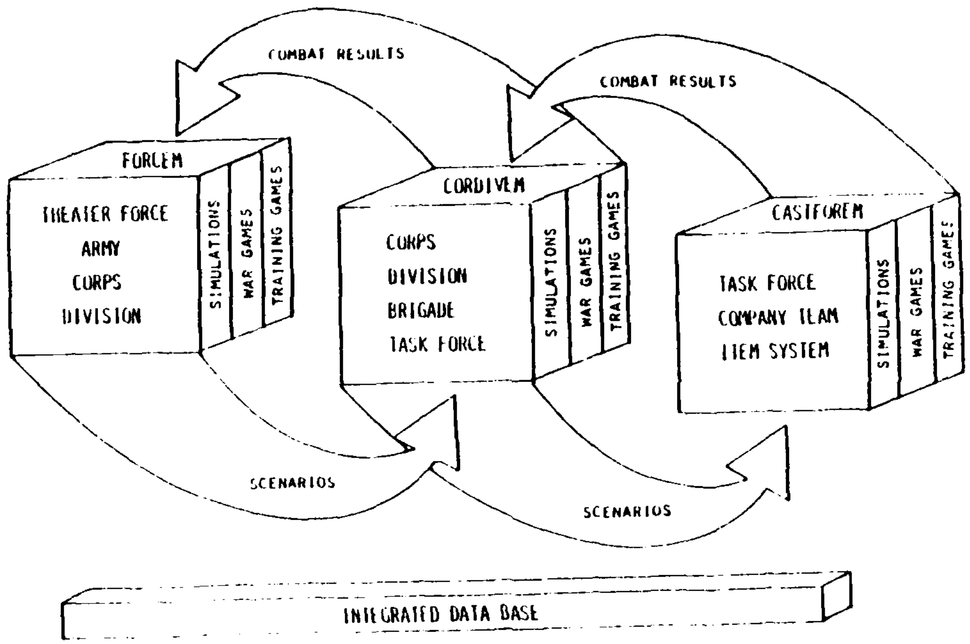


FIGURE 11

HIERARCHY OF ARMY MODELS
SOURCE: Livingston (41,p.89)

current U.S. Army combat models. This will be accomplished in three sections. Section one will review some attempts at identifiying organizational aspects of combat. Section two will briefly review how combat is modeled today. Finally, section three will propose a method of incorporating the LST results into a specific model. It must be understood that, due to the limitations mentioned in Chapter III, the proposed methodology is still very hypothetical and will require further refinement as the data becomes available.

B. HISTORY

The ability to model complex aspects of military organizations does not exist today. Part of the problem has been the inability to model individual soldier behavior on the battlefield. Specific attempts to capture these behavioral characteristics quantitatively have been attempted by modelers such as H.K. Weiss [68] and T.N. DuPuy [23]. In Weiss' BRL Report he identified specific characteristics of the soldier. Using these characteristics as variables he developed mathematical formulas to model these characteristics such as freshness and morale. Dupuy presented an analytical methodology using an equation he called the Quantified Judgment Model (QJM). In this model DuPuy used two behavioral variables which represented surprise and combat effectiveness. He was able to verify his methodology using historical combat data. In both instances only a

small portion of the human element was present from the organizational standpoint.

Another approach to researching combat has been to question soldiers as to why Army organizations were able to function in combat. Examples of this research were the World War II studies of S.L.A. Marshall [48]. In his interviews of soldiers as they came out of combat, he was able to identify particular characteristics of units and people in combat. He discovered, among other things, that information and unit cohesion play an important part in the success or failure of units in combat. Although the interviews are detailed and colorful, very little quantifiable data was presented for the military modelers to use. Another book, Crisis in Command: Mismanagement in the Army [27], by Gabriel and Savage, looked at specific problems of command during the Vietnam era of the U.S. Army. Again quantifiable characteristics were not presented, but specific variables from that type of combat were presented. The final example, also from the Vietnam era, is Hauser's book America's Army in Crisis [30]. Again, what is presented are those characteristics of the Army organization as it deals with the environment of today. He has provided examples of how critical parts of the organization react to the environment of the 1960's. In all of these studies particular parts of the organization have been identified as critical to its

operation. However, no single method of quantifying and explaining interactions within the organization has been provided.

C. TODAY'S MILITARY MODELS

Today's military models come in many types, levels, and degrees of resolution as seen from Figure 11. Models are used for a variety of purposes, but the general purpose is to answer questions about some future state of a process [63, p. 9]. For clarity, the terms model and combat model in this chapter can be considered synonymous. An excellent listing of modeling terms can be found in Livingston [43, pp. 19-24] and the glossary of Honig [31].

Different models are used for strategic planning than for analyzing cost effectiveness for particular weapons systems. However, the process that should be followed is very precise. A recent explanation of the military analysis process by Robert Doty can be found in a book entitled Systems Models for Decision Making [61]. In his chapter, Doty discussed the basic steps of the analysis process and the use of models in this analysis effort [20].

When selecting a specific combat model to use during analysis, certain limitations of each model must be considered. Livingston [43] has compiled a listing of model limitations that should be reviewed when selecting a model. As an example, there are three types of models in use today

for analysis purposes: the war game, the simulation, and the analytical model. A war game is used as a diagnostic tool to reveal problems in military organizations. It has the advantage of allowing human decision-making and is used for training purposes. It has the disadvantage of not being able to be replicated. Additionally, a data base has not been established by any Army agency to record the results of war games.

The simulation is used in the predictive model to determine feasibility of a particular course of action. It has the advantage of being replicated. Additionally it has the advantage of modeling events and activities stochastically. Its disadvantage is that once initiated no human interact or input can be made.

The final type of model, the analytical model, is similar to the simulation in that it does not allow any human interaction. It has the disadvantage of being more abstract than either of the other models due to its use of mathematical equations for events and activities.

Another method of cataloguing models was presented in an article by Seth Bonder entitled, "An Overview of Land Battle Modeling in the U.S." [11]. Of particular interest are his charts which attempt to classify the processes of combat. Included in the chart is a method for identifying whether a model exists for that process and whether that model has been validated. Although these charts are over ten years

old, this technique for identifying models is valid. A similar technique could be used today in an attempt to identify where the Army is in the modeling of combat processes.

One particular solution to the model of organizational aspects has been proposed by R.K. Huber in a paper presented at the Naval Postgraduate School, entitled, "A Systems Analyst's View on Force Structure Planning" [32]. His paper discusses a conceptual method for integrating organizational issues into defense and force structure planning. The author has identified a quantified method which takes into account the fact that military production requires dynamic analysis. What Huber has proposed is the concept of "compound gaming" (see Figure 12). This concept utilizes the strengths of both simulations and war games to provide the necessary information in a mission-oriented context. In his conclusion he specifies the need for a framework that permits investigation of interdependencies of organizations.

D. LST AND FUTURE COMBAT MODELS

Of critical interest to the Army is using the LST results to predict combat effectiveness of units and equipment. One method for predicting combat effectiveness is to incorporate the results of organizational analysis, conducted in simulated combat, to combat models. As stated in Chapter III,

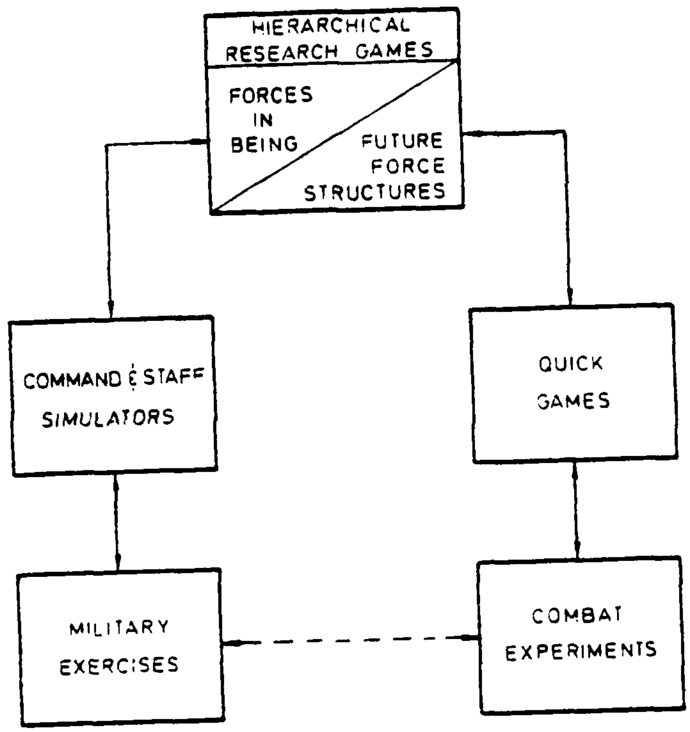


FIGURE 12

COMPOUND GAMING

this analysis of organizational processes could be done using a field exercise and/or a training simulator such as CATTS. The combat model this thesis proposes is the Simulation and Tactical Alternative Responses (STAR) [53].

This section will outline an approach to combining LST with the STAR model of the future. What is needed first is an explanation of the steps which must be accomplished prior to running this model.

The first step will be for Army modelers and decision-makers to decide on the critical components and processes in combat. One critical factor which must be considered is the resolution of the model to be used. A high resolution model will represent the individual soldier in battle. A low resolution model might represent brigades or divisions as the basic item. What is needed is a model that will have variable resolution. If a unit is fighting in combat, individual vehicle/soldier resolution may be required. If the unit is required to move, the level of aggregation may be the company or the battalion. The significance of this to LST is that the level of analysis to date focuses on the battalion. Therefore, decisions made at the battalion can be assessed for particular processes, such as the time it takes the battalion commander to make a decision to move a company. LST results cannot be used for item level resolution until the proper assessment has been accomplished at the organism and group levels.

Another aspect that must be considered prior to using a particular model is the length of the battle that will be modeled. For example, currently the STAR model evaluates individual battles which last approximately thirty minutes. Given this restriction, to include the ingestor process as critical to the battle is unnecessary. The soldier in battle must fight with what he has available.

Once the level of analysis has been decided, the proposed ISSRT organization could provide the necessary quantified data on these processes and relationships. If the data for the proposed scenario is not available, an assessment on the correct unit must be conducted. This may be required due to changes in type of units being evaluated or the duration of the combat. One specific advantage of this approach is that data from actual military organizations will be utilized. The data that is input into these models will be more realistic.

The next step that must be taken is to identify the framework which will allow these results to be incorporated. One such framework which is now being utilized by STAR is a programming language called SIMSCRIPT [58].

SIMSCRIPT is a programming language originally developed by RAND Corporation for discrete-event simulation [58, p. V]. Today, it is a highly versatile programming language which allows a very powerful list-processing capability. What this means is that it has the capability to keep track of many

events all happening at the same time. A definition of key terms will illustrate its usefulness. Of particular interest to this thesis is its similarity to the living systems theory vocabulary and processing framework. The following list of terms is provided:

1. An Entity is an element or component of an organization. The entity may exist permanently in the organization or only temporarily. An entity in STAR can be a soldier, a tank, or a battalion. There is no limit to the number of entities an organization can have.

2. An Attribute is a value assigned to entities. These values may be constant or variable. There is no limit to the number of attributes an entity may possess. An example of an attribute for a battalion could be the number of aerial platforms currently operating with the battalion.

3. An Event is used to keep track of processes within a model. It is characterized by a start and duration time, which is determined by the activity associated with the event. An example of an event in STAR is communication, which is scheduled whenever a unit needs to relay information.

4. A Set can be used to model relationships of entities. Sets may exist for any specified period of time. The set of companies and their attributes are maintained as a battalion entity.

Some additional features of SIMSCRIPT used in STAR are described in a manual by Perry and Kelleher [53]. One hypothetical use of LST in STAR is explained below.

If a company wants to move, they must request permission from battalion. In order to ask permission, the Commander must establish communications with battalion and obtain an answer. The communications event checks the attributes of radios in the company and the battalion to see if they are capable of sending this message. Once the message arrives at battalion the decision, as currently modeled, occurs instantaneously and another communication event is scheduled from battalion to the company.

A potential use of LST is to describe the processes which occur at battalion to make this decision. Specifically, the quality of the decision (based on information available) and the time to make the decision may be determined using the LST framework. By identifying the necessary processes and the delays within the battalion, more accurate information concerning organizational aspects can be modeled. This same format can be used for other events that require battalion action, such as resupply.

Quantifiable data is needed on battalion processes and relationships in combat to realize this capability. It is essential that results from field exercises (e.g., National Training Center) be used to develop data for the LST Processes.

Only after this data is available can the processes be reasonably incorporated in a combat model such as STAR.

E. SUMMARY

This chapter has attempted to provide a framework in which organizational aspects can be included in future combat models. The history and current status of combat models were reviewed. A hypothetical outline of how LST results could be applied in a combat model of the future was presented.

Combining personnel knowledgeable in GST, LST, and combat modeling is essential today. Models and analysis using the LST results may provide more realistic data upon which decisions can be made. The LST framework provides a systematic approach to examining internal processes of military units. The ability to model these relationships exists today through the use of the SIMSCRIPT programming language. This combination will provide a more holistic analysis of combat.

V. CONCLUSIONS

A. SUMMARY OF ACTIONS

The foundation for utilizing Living Systems Theory in the Army has been laid. This thesis has proposed a framework for using the LST research in combat models. The major portion has been devoted to explaining Living Systems Theory as a means for identifying organizational aspects of Army units. Both General Systems (GST) and Living Systems Theory (LST) can be used to integrate the research of organizations and combat models.

In the introduction, and in Appendix A, the general system approach is explained as a way of looking at systems from a holistic perspective. Of particular interest are the patterns which GST has developed for explaining how and why organizations function.

Chapter II was used to explain LST, suggesting a more quantifiable framework than GST. The essential aspects of LST are the explanation of Miller's 19 subsystems and the relationships which they exhibit. This particular framework has been used by the Army in an attempt to better describe and diagnose battalion problems in peacetime. However, the research is not complete. Future needs have been identified which will help to quantify those processes and relationships that are critical to military units in combat.

In the final chapter specific attempts to model organizational aspects in combat models are reviewed. A proposed framework for incorporating the results of LST research is provided as a road map for future Army modelers to use. Together these chapters give a foundation for systematically integrating organizational aspects into combat models.

B. RESEARCH AND FUTURE NEEDS

The need for a permanent systems organization must be resolved. The need to improve existing LST data and centralize applications of this theory is essential. As a guide the following recommendations have been made:

1. Decision-makers must identify the critical processes necessary for units to win in combat.

2. An interdisciplinary search of organizational theories that are applicable to the identified processes must be made and included in the LST research.

3. The data gathering instruments (questionnaires and interview format) must be simplified in order to allow minimum unit disruption.

4. The analysis of the data must be combat related. It must be quantified to the extent that relationships between processes can be measured.

5. The integration of these analysis results with combat models must be made. A conceptual framework has been suggested using SIMSCRIPT and a version of the STAR combat model.

6. Continual refinement must be made of both the LST data and the framework for incorporating this data into combat models.

The accomplishment of these six recommendations will allow the Army to take advantage of this theory and improve the modeling of organizational aspects.

C. INSTITUTIONAL IMPLICATIONS

In a recently published article by Colonel Dandridge M. Malone he concluded that:

> Soldiers need to write their own doctrinal literature about 'how to run an organization' . . . . We need some help from the theory and research of those (management and organizational) scholars, but what we need most is something that comes from our bedrock, that comes from all we have learned in 200 years and recognizes our uniqueness [45, p. 41].

Living Systems Theory provides a conceptual framework for visualizing this doctrine. The help we can get from the scholars will allow us to "fill in" this framework based on the assessment we make on Army units. The results of assessments using LST has indicated this approach can help the leaders to identify and diagnose unit problems. Education is needed to allow all Army leaders to take advantage of this holistic approach. LST provides a "new set of 'lenses'" which may assist Army leaders in dealing with the complexitiies of today's Army [22, p. 2].

At the same time, this framework may assist the commander in becoming a more intelligent consumer of new organizational

theories. Lorsh [42] has suggested that managers, including Army leaders, must become more educated and critical of the "tools" that behavioral scientists are providing. One approach to evaluating these new approaches would be to have our own "framework" to evaluate these new ideas. An LST framework built around Army organizations would allow such ideas to be assessed.

LST is a conceptual framework which contains many hypotheses and unanswered questions. Through the Army's use of this theory, a more complete analysis of the theory can be accomplished. The results of outside research which is being conducted using LST must be evaluated for applicability to the Army. As an example, the work done on LST applications to Health Services could have tremendous impact on the medical units of the Army. The refinement of LST can be accomplished as the Army attempts to solve its problems using this approach.

Finally, models are needed by the decision-makers and will continued to be used to a great extent in the future [43, pp. 15-16]. Combat models do have limitations in the modeling of organizational aspects. The use of LST results in these combat models will add realism and quantification of processes that are critical to the organization in combat.

D. FINAL REMARKS

The author does not presume completeness of the LST framework; nor have all the future problems of implementing LST results in combat models been resolved. However, the Army is applying LST to identify and diagnose Army battalions. This important first step has been taken and shows promise to assist the Army in understanding the organizational aspects of battalions. Continual communication is needed in the Army among combat modelers, the LST researchers, and the decision-makers. Each of these people play an important part in insuring that LST is made useful to the military. This research effort has attempted to identify where LST has come from, where it is today, and how the Army can utilize it in the future.

As in modeling, LST research and applications to the Army will need to be continually refined. Similarly, the models the Army uses are continually being refined and enriched. One of these enrichments may be the ability to model the organizational aspects that are critical in combat through the use of a LST framework.

APPENDIX A: GENERAL SYSTEMS THEORY

A. INTRODUCTION

The Army needs a framework that will incorporate theories of organization to better describe, explain, and deal with the issues of today's military organizations. One approach which has been proposed and is currently being expanded is General Systems Theory (GST). GST was originally presented by von Bertalanffy in 1937 [5]. Today, GST connotes many things to different people depending on the discipline in which they work and the education which they have received. As shown by Figure 13, GST is an approach to investigating the properties of systems using the knowledge, concepts, and methods from many fields of science.

The purpose of this section is to show how GST can be used to tie organizational aspects into a unified approach for understanding the issues of today's Army. This will first require an explanation of the general purpose of GST. Next, some of the major concepts of GST will be explained. Finally, the method which GST proposes for integrating organizational aspects will be explained, using examples from Army organizations.

B. PURPOSE OF GENERAL SYSTEMS THEORY

The purpose of General Systems Theory is to facilitate the exchange of knowledge among disciplines. As expressed

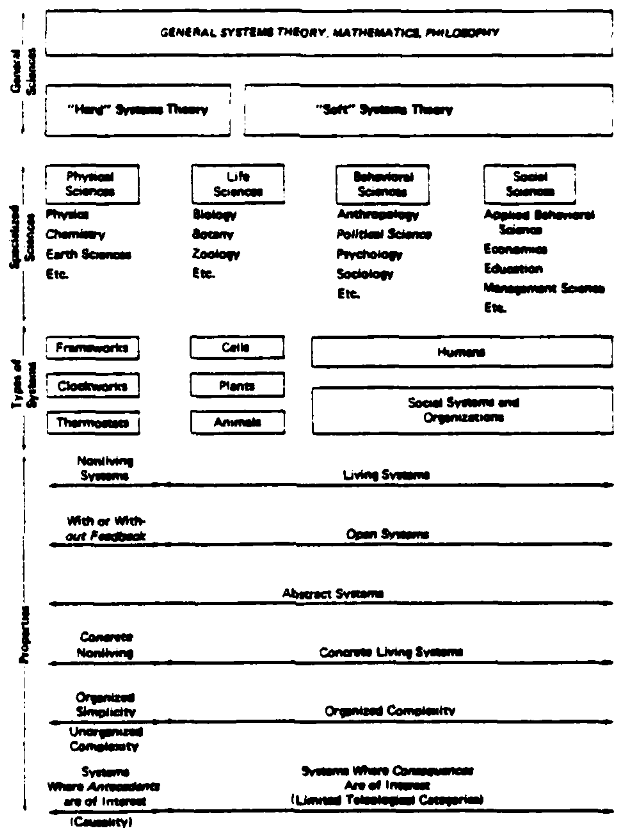


FIGURE 13

A Taxonomy of Sciences and Systems

SOURCE: van Gigch, J.P. [28, p. 39]

by von Bertalanffy, the major aim is that since there is a general tendency toward integration in various sciences, the development of unifying principles which run "vertically" through many fields of science can lead to a much needed integration of scientific education [5, p. 38]. Expressed in more general terms, GST is essentially an attempt to provide the scientific cc munity with a set of assumptions and propositions about the nature and dynamics of phenomena in general [54, p. 31].

The term "system" is the central concept used in the general systems approach to unifying the sciences. GST defines "system" as:

> A whole characterized by some degree of relationship between its parts [55, p. 103].

In contrast, Webster's dictionary defines system as:

> A complex unity formed of many often diverse parts subject to a common plan or serving a common purpose; an aggregation or assemblage of objects joined in regular interaction or inter-dependence; a set of units combined by nature or art to form an integral, organic, or organized whole; an orderly working totality [69, p. 2562].

As one of thirteen definitions of a system, this definition by Webster incorporates many ideas concerning systems which may not be necessary. The difference between these two definitions underscores the three focuses of GST. In order to appreciate the general systems approach, these focuses need to be clarified.

First, the general systems approach studies systems in terms of reality, the universe, and the cosmos, referred to as the meta-level. The main purpose of this focus is to avoid the narrow vision of specific disciplines; that is, to avoid not seeing the forest through the trees. What is one complete system in a particular situation may only be a part of a much larger system from another perspective. GST initiates a study of a system by defining the system in a very broad, general framework. Using interdisciplinary research it continually defines and attempts to complete this framework. This process is similar to the method used in chemistry to complete Mendeleyev's periodic table of elements. GST attempts to provide a view of the whole phenomenon that is comprehensive enough to encompass both the system and the environment which can affect that system.

Second, GST focuses on patterns of change, referred to as meta-patterns, characterizing reality. It assumes only patterns, spectra, and continua. Figure 13 shows this focus by picturing systems perspectives as continuous lines. By assuming a continuous spectrum of each system property, various sciences can be linked. Again using Figure 13, communication between the sciences, such as physics and political science, can be initiated by establishing how they visualize these different perspectives.

Finally, the general systems approach focuses on providing a common language to explain and describe systems,

referred to as a meta-language. Each discipline, such as physics, chemistry, or psychology, has developed its own definitions. These are usually expressed as absolutes or given as assumptions. Many of these defintiions have required change when it is discovered a larger more universal perspective can be demonstrated. The general systems approach has no absolutes. As a result, communication among disciplines can be initiated. Examples of general systems terminology and concepts will be explained in the next section of this appendix.

All three of these focuses may lead one to believe GST is an approach which attempts to deal with complex relationships in a very superficial manner. If this were the case, the utility and existence of this theory would have long ago disappeared. Today the general systems approach is more detailed, due to increased knowledge of our universe. The following definition exemplifies this approach:

> The general systems approach is an explicitly unified meta-disciplinary means for describing, explaining, understanding, and dealing with these complex relationships, based on a fundamental view that the world in which we live is organized and reflects the basic perception that reality as a whole is intrinsically unified, integrated, holistic and harmonious [55, p. 2°].

In conclusion, the aim and thrust of general systems research is to holistically identify and delineate the essential principles of systems, and develop a meta-disciplinary perspective. This perspective contains concepts in a framework that allows communication of ideas across many

scientific boundaries. At present, many concepts have been developed and will be discussed in the next section to show their relevance.

C. GST CONCEPTS

According to von Bertalanffy organizations are characterized by notions of wholeness, growth, differentiation, and hierarchical order [5, p. 47]. He went on to say that systems theory, due to its general nature, is capable of dealing with these and other non-quantifiable terms, unlike conventional sciences. GST was able to expand the assumptions of specific system properties which conventional scientific models were not able to do. Some of the more important properties of systems which have been conceptualized using the general systems approach are:

1. Living systems, versus non-living systems, are usually endowed with biological functions such as birth and death. This concept is the basic tenet of Miller's Living Systems Theory and was explained in Chapter II.

2. Concrete systems, versus abstract systems, are systems which contain elements, sometimes called subsystems or components, which are observable and can be measured in space/time dimensions. Abstract systems may contain both elements which are observable, and concepts which are perceptions from a particular perspective. These perceptions must be explained in order to be understood.

3. Matter-energy in general systems terms refers to a combination of material and resources necessary for all living systems. Matter is anything that has mass and occupies space. It refers to material, such as food or fuel, which the system needs and uses. Energy is the ability to do work. Matter may have kinetic, potential or rest mass energy. All living systems must have matter-energy in adequate amounts to sustain themselves.

4. Information in general systems terms is used in the formal information theory sense. The unit of measure for information is the "bit" which is used to reduce uncertainty. All living systems must have information in varying amounts. Information is carried on "matter-energy markers" such as words or sounds.

5. Open systems, versus closed systems, are systems that affect or are affected by their environment. Closed systems are systems which are viewed in isolation and have no environmental interaction. According to GST all living systems are open to a certain degree and as such cannot be viewed in isolation.

6. Entropy in general systems terms is a measure of disorder and randomness. Closed systems must always increase in entropy because matter-energy and information are progressively destroyed. Open systems allow inputs of matter-energy and information and thus are able to resist entropy.

7. Equilibirum, in general systems terms is a dynamic process which involves maintaining a state of relative balance with an environment. This is differentiated from the static steady state. For a closed non-living system equilibrium is dependent on its initial condition and the static steady state is reached very deterministically due to entropy. Open systems maintain and achieve equilibrium through dynamic interchange with their environment and never have a static steady state.

8. Equifinality suggests that a final state of an open system may be reached from different initial conditions and in different ways [5, p. 40]. It may be postponed by maintaining equilibrium with the environment. Living systems have the capability to move away from equifinality through increased order and organization [5, p. 41].

9. Cybernetics, is a term coined by Norbert Wiener in the 1930's, and is defined today as:

> A set of assumptions and propositions concerning the process and effect of communication and control in those pehnomena which are able to regulate their own and sometimes other relationships to some extent [55, p. 33].

Usually involving some form of feedback, cybernetics is a specialized part of general systems thought. It has concerned itself with the communication and control aspect of systems. For a more specific explanation and applications, see Wiener [70], Ashby [4], and von Foerster [25].

10. Variables in the general systems approach must be viewed in relative terms. Parameters or structures will be relatively invariant, while processes and variables are relative variants. All variables can be observed given a certain amount of time, change in the system, or level of reference from which the system is viewed (see next section).

11. Hierarchy, or level of reference, in general systems terms is used to represent systems according to recognizable specific criteria. Various categorizations have been attempted, usually in terms of increasing system complexity. Examples of systems hierarchies have been Boulding's nine levels of complexity as explained in "Skeleton of Science" [12]. These levels are based on the functioning of components. Miller has identified seven basic levels of living phenomena. His levels are based on certain fundamental forms of organization which living systems possess [51, pp. 25-46]. One caution, which must be emphasized, is the need to specify at what level of reference and according to whose model the system is being viewed. As an example, this thesis is focused on Miller's fifth level, the organization.

12. Emergents in general systems terms refers to the characteristics of a whole system. According to GST, a whole system is more than the sum of its parts. Systems when viewed at a higher level of reference will contain emergent characteristics not found in lower level systems [15, p. 55; 51, pp. 1036-1038].

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13. Boundaries in open systems are used to differentiate the system from its environment. Boundaries maintain a certain amount of linkage between the system and the environment. Boundaries may be spatial, temporary, functional, or abstract depending on the observer and his level of reference.

All of these concepts provide an underpinning from which the general systems approach receives its value. However, as von Bertalanffy has suggested, the ability of GST to improve our knowledge of organization is the most important function [5, p. 49]. The use of the general systems approach to explain patterns of organization has many applications. In the next section, ways in which GST can be applied in organizations such as the Army will be illustrated.

D. THE GENERAL SYSTEMS APPROACH AND VALUE TO ORGANIZATIONS

GST represents a conceptual framework through which organizations and societies can be viewed. Systems, such as social, cultural, geopolitical and military, all have characteristics which go beyond the complexity of machines. Of particular interest here are these systems' capabilities to establish their own goals, communicate with the environment and make conscious decisions. GST is used to explain these phenomena in organizations by observing their patterns. Researchers of organizations attempt to answer how and why organizations change through the identification of patterns. Four patterns which have been identified are:

metamorphosis, morphogenesis, morphostasis, and organization [55, p. 120]. In each of these patterns the researchers are concerned with the amount of matter-energy and information an organization used to affect these patterns of change.

The first pattern, metamorphic change, is concerned with the formation and destruction of organizations. In the military this type of change may not be controlled from within the organization. For instance, the people, through Congress, decide when new organizations are necessary or when they are no longer needed. Very little research has been done on this pattern and it will therefore not be addressed.

The second pattern, morphogenic change, is concerned with adaptive change. Buckley has identified two types of morphogenic change -- destructive and democratic [49, p. 18]. Destructive change, or MG_1, has the objective of developing better goals and more regulation for the organization through destructive means. An example of this was the Civil War. Democratic change, or MG_2, has the objective of developing better goals and regulation in an organization using discussion of ideas and joint decision-making. Here, the researcher is attempting to determine how and why the organization "adapts."

The third pattern, morphostatic change, is concerned with maintaining equilibrium. The goal of the organization,

using this approach, is to prevent change or at least to maintain its present structure. In looking for this pattern, the researcher is asking how and why the organization maintains control within certain limits. As proposed by March and Simon [47, p. 110], the means by which an organization induces individuals to "produce and participate" contributes to morphostatic change.

The final pattern, organization change, is concerned with changes in and maintenance of relationships. The goal of organizations using this approach is to maintain relationships. In looking for these patterns, the researcher asks how and why the organization maintains different relationships. Five factors have been identified which enable the organizational researcher to classify change on the basis of relationships. The first of these is the ability to define and distinguish internal relationships within systems. Rousseau [56] has suggested a multi-dimensional framework for visualizing internal relationships of technology and the organization. Each of the blocks in her framework represents a relationship which must be evaluated. As with other patterns of change, GST suggests the amount of matter-energy and information used by the organization to maintain these relationships may be a way of measuring these relationships.

The second factor of organizations which must be considered is the nature and extent of external relationships. As Lawrence and Lorsch [40] discovered, an organization's

external complexity will affect how that organization operates. For example, fighting a short war in the desert will require a different organization than fighting an extended war in Europe. The ability to differentiate different external relationships and the diversity of these relationships will assist in determining the proper internal organization.

The third factor which has been identified is a set of limitations on the kinds of relationships organizations can exhibit. Certain relationships are concrete while others are abstract. Leaders during combat must make decisions based on perceived and concrete relationships. The more concrete these relationships can get, the more verifiable are the leader's decisions. The ability to differentiate these types of relationships and use them may be measurable.

The fourth factor of organizations is the extent to which relationships and changes result from the system or from the environment. Change is observed if the researcher can distinguish whether the system is being acted on or to what extent another system is acting on that system. The differences in the amount of matter-energy and information that are entering or leaving an organization should determine if this factor has changed.

The fifth, and final factor, which must be considered concerns the ability of an organization to regulate its own relationships through time. As mentioned earlier, the

ability of an organization to regulate itself has been explored extensively in cybernetics. In addition, Katz and Kahn's description of leadership [37, pp. 334-5] suggests a method of evaluating these relationships. Explaining how and why a leader regulates the relationships of his organization is the goal of research in this factor. Katz and Kahn suggest the leader's use of "expert" and "referent" power need to be measured when evaluating this relationship.

The general systems approach is useful for explaining all four basic patterns of change in organizations. The ability to differentiate these specific patterns is the first step in understanding organizations. GST provides a framework for differentiating these patterns. Specific examples of how GST has been applied can be found in Klir [38], Cavallo [19], and Rechmeyer [55].

E. CONCLUSION

The purpose of this appendix was to explain GST and show how it forms the basis of the Living Systems approach. This was accomplished by describing the general systems approach. An understanding of the thrust and basic concepts was provided. The value of the general systems approach to organizations was described. Specifically, an explanation of the patterns of change organizations continually undergo was described. These same patterns appear in LST and have been identified in Miller's book.

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9.	Mr. Walt Hollis Deputy Under Secretary of the Army (Operations Research) Department of the Army, The Pentagon Washington, D.C. 20310	1

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22. Chief 1
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